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# An Empirical Analysis of Income Convergence in the European Union*

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**Abstract**

In this paper, we investigate the convergence process within the European Union (27 countries). More particularly, we study the convergence process of the new entrants from Central and Eastern Europe and of the 15 Western countries between 1990 and 2007. Applying a panel approach to the convergence equation derived by Mankiw et al. (1992) from the Solow model, we highlight the existence of heterogeneity in the European Union and show that new entrants and former members of the European Union can be seen as belonging to significantly different groups of convergence. The existence of heterogeneity in the European Union or the Eurozone might affect their stability as the recent Greece's sovereign debt crisis illustrates it.

JEL Classification: O47, O52
Keywords: Economic Growth, Convergence, European Union, Panel Approach

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# 1 Introduction

The idea of integrating Central and Eastern Europe countries in the European Union dates back to the early 1990's. On the first of May 2004, ten new countries[1] joined the European Union. Among these ten countries, eight belong to Central and Eastern Europe. Less than three years later, on the first of January 2007, two other countries from Eastern Europe, Bulgaria and Romania, entered the European Union which is now composed of 27 countries. For the first time in its history[2], EU opened its doors to countries from the former Eastern bloc.

Less than fifteen years after the collapse of the Soviet bloc in 1990 and the resulting shift from a planned economy to a market economy system, some Central and Eastern Europe countries were allowed to join the European Union which was until then exclusively composed of Western countries.

Obviously, candidates to the European Union membership have to meet some political and economic requirements. In particular, applicants must possess stable institutions that ensure the respect of democracy and human rights, a viable market economy system and the capacity to cope with competitive pressures.[3] If these constraints have forced the new entrants from Central and Eastern Europe to achieve some kind of structural and institutional convergence toward Western standards, there still remains a long way to cover before they can catch up their backwardness in terms of income per capita.

While the membership to European Union might be expected to speed up the process of convergence to the Western Europe countries in terms of per capita income levels, we can wonder if the income level convergence must be a consequence of membership or a necessary prerequisite. Indeed, the European Union does not impose any conditions on the process of income convergence before joining the Eurozone. A central question is then to verify if new entrants already exhibit income convergence with the existing members of the European Union or if we can identify the existence of two heterogeneous groups in terms of convergence process within the European Union. Too large heterogeneities within the European Union or the Eurozone might be problematic as the recent troubles surrounding the Greece's sovereign debt have underlined it. As a consequence, testing the absence of heterogeneity, among others, in terms of income convergence might be of prime importance before a country is allowed to join the Eurozone.

[1] These ten countries are the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovenia and Slovakia plus Cyprus and Malta.

[2] If we except the somewhat particular case of East Germany.

[3] See Article 49 of the Treaty on European Union (Treaty of Maastricht, 1992) and the criteria set by the European council in Copenhagen (1993).

In this context, this paper focuses on the process of convergence in terms of per capita income levels in the European Union. We will make use of regression models which have been developed in the growth convergence literature to check whether the countries in the European Union in 2010 are already converging . More particularly, we examine the convergence process of two distinct groups i.e. the 15 Western countries and the new entrants coming from the former Eastern Bloc.
Our paper is structured as follows. We first introduce the theoretical Solow model, a short review of the literature on growth convergence, estimation procedures and convergence within the European Union. The last sections of our paper are dedicated to the description of our methodology, our empirical results and to their analysis.

# 2 Literature Review

The debate on convergence between neoclassical and new growth theory proponents has led to a large number of definitions of the term convergence and to a very well developed literature on the topic (for a thorough review of the literature, see Islam (2003)). For our analysis, we consider the Neoclassical Growth Solow model (1956).
The production function considers two factors of production, namely labour $L$ and capital $K$. This function has two important properties. First, it exhibits constant returns to scale and, second, it assumes diminishing returns to each factor. This second assumption is crucial for the model and especially in the study of convergence. We include a technology variable $A$ which is labour-augmenting.

$$Y(t) = K(t)^{\alpha}(A(t)L(t))^{1-\alpha}$$

If we express the variables in intensive form (i.e. per effective worker) the production function is then $y(t) = k(t)^{\alpha}$ and the evolution of the capital can be written as:

$$\begin{aligned} \dot{k}(t) &= sy(t) - (n+g+\delta)k(t) \\ &= sk(t)^{\alpha} - (n+g+\delta)k(t) \end{aligned}$$

where $s$ is the constant saving rate, $n$ the growth rate of the population, $g$ the rate of technological progress and $\delta$ the rate capital depreciation. Note that $s$, $n$, $g$ and $\delta$ are exogenous and thus determined outside the model.
We can derive that $k$ converges to the following steady state value:

$$k^* = [s/(n+g+\delta)]^{\frac{1}{1-\alpha}}$$

and then plugging $k^*$ into the production function, taking the logs and dividing by labour we find the steady state income per capita:

$$ln(\frac{Y(t)}{L(t)})^* = lnA(0) + gt + \frac{\alpha}{1-\alpha}ln(s) - \frac{\alpha}{1-\alpha}ln(n+g+\delta)$$

Thus, at the steady state, the income per capita depends positively on the saving rate and negatively on the population growth rate.
Moreover if we consider that the share $\alpha$ of capital is around one third while the share of labour is two third, then the elasticity of income with respect to $s$ is around 0.5 and the elasticity with respect to $(n+g+\delta)$ is around -0.5. Rearranging, we end up with the following form:

$$\begin{aligned} ln(y(t)) - ln(y(0)) &= (1-e^{-\lambda t})\frac{\alpha}{1-\alpha}ln(s) - (1-e^{-\lambda t})\frac{\alpha}{1-\alpha}ln(n+g+\delta) \\ &- (1-e^{-\lambda t})ln(y(0)) \end{aligned}$$

where $\lambda$ is the rate of convergence.
The growth rate depends positively on the saving rate and negatively on the growth rate of the population and on the initial income (i.e. the lower the initial income the higher the growth rate).
One important distinction is undoubtedly the difference between absolute (or unconditional) and conditional convergence. The first approach assumes that countries are homogeneous so that they share the same steady state even if they do not share the same income per capita at a certain moment. Consequently, countries with lower initial level of GDP should experience higher growth rates than initially richer countries. On the other hand, conditional convergence makes no assumption about shared steady states so that other parameters might explain differences in steady state levels of per capita income. As a consequence, countries may converge to their own steady state which is a function of some other variables. In this framework, a richer country could be characterized by a higher growth rate than a poorer country if the former is farther from its steady state than the latter (this means in this case that the steady state of the rich country would be much higher than that of the poor country).
Baumol (1986) introduces in its pioneering paper a third kind of convergence that is club convergence (see Galor (1996) for a more formal analysis of club convergence). Club convergence implies that there may exist many per capita income equilibria to which groups of countries converge. As opposed to the unconditional convergence, this approach allows more than one unique equilibrium while it does not suppose that each country has its own equilibrium as in the conditional definition of convergence. The search for determinants

of the belonging to one club or another has also led to an abundant literature (see among others Durlauf and Johnson (1995), Desdoigts (1999)).
Early papers trying to empirically investigate the convergence of different countries mainly focus on what is called $\beta$-convergence. This measure of convergence takes its name from the fact that it is based on the value (and as importantly on the sign) of the beta estimates from a regression of the growth rate of the per capita GDP on the initial level of per capita income . More recently, another type of convergence has been put forward (see for instance Quah (1993)) which is based on the evolution of dispersion of per capita income across countries. This kind of convergence is called sigma-convergence. Besides the many definitions that have been assigned to convergence, the empirical literature has also given rise to different econometric approaches to the estimation of convergence. Seminal papers such as Baumol (1986) or Mankiw et al. (1992) use cross-sections to estimate $\beta$-convergence using two different models. Mankiw et al. (1992) take the theoretical Solow model as a starting point for testing convergence in terms of per capita income levels. Consequently, they introduce in their regression the determinants of the steady state under the Solow framework. Under the assumptions of the Solow model, we can write the steady state of per capita income $y^*$ as:

$$y^* = A(0)e^{gt}[s/(n+g+\delta)]^{\frac{\alpha}{1-\alpha}}$$

where A(0) is the initial level of total factor productivity, g is the growth rate of A, s is the saving rate, $\delta$ is the depreciation rate and $\alpha$ is the income share of the capital in the Cobb-Douglas production function. Mankiw et al. (1992) then derive the equation which allows them to test convergence from the Solow model.

$$lny(t_2) - lny(t_1) = (1 - e^{-\lambda t})(lny^*(t_1) - lny(t_1))$$

where $y$ is the per capita income.
Substituting the value of $y^*$ from the steady state equation, they get the growth-initial level equation:

$$\begin{aligned} lny(t_2) - lny(t_1) &= (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha}ln(s_{t_1}) - (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha}ln(n_{t_1} + g + \delta) \\ &- (1 - e^{-\lambda t})lny(t_1) \end{aligned}$$

The parameter $\lambda$ which can be estimated from the value of the estimated $\beta$[4] is interpreted as the speed of convergence[5]. In addition, from a theoretical

[4]We refer to the term $\beta$ to denote the coefficient related to the initial level of income. This is in line with the definition of $\beta$-convergence.

[5]$\lambda$ is easily calculated as: $\lambda = -ln(1+\beta)/t$

point of view, we can notice that the coefficients related to the saving rate and to the combination of the population growth rate, the depreciation rate and the growth of total factor productivity sum to zero.
In order to estimate their regression, Mankiw et al. (1992) allow the saving rates and the population growth rates to differ from one country to another. However, they fix the sum of the depreciation rate and of the growth rate of total factor productivity to be equal to 0.05 for all countries.
A few years later, Islam (1995) develops a panel data approach to $\beta$-convergence built on the same regression and data as Mankiw et al. (1992). As Islam (1995) argues, the advantage of the panel approach is that it allows to account for the initial level of total factor productivity (A(0)) which should be included in the individual effect. To apply methods for panel data to the dataset[6], Islam divides the period into five subperiods of five years[7] each.
In addition to cross-section and panel data methodologies, convergence study has also recently been evaluated using time-series techniques (see among others Evans and Karras (1996)).
Regarding the European Union, several papers have investigated income growth convergence. Recently, Mora (2005), Fischer and Stirbock (2006) and Battisti and Vaio (2008) have studied optimal regional convergence clubs in the European Union. Their primary goal is to define clubs of regions within the European Union sharing the same characteristics in terms of income growth convergence without assuming any *a priori* restriction on the composition of these potential clubs. Another part of the literature has focused on the convergence process of new entrants from Eastern Europe. Using a cross-sectional approach, Matkowski and Prochniak (2007) find a clear (absolute) $\beta$-convergence within the group of new member countries while their convergence process toward members seems slower. Kocenda et al. (2006) and Ingianni and Zdárek (2009) also show evidence of $\beta$-convergence among new entrants countries as well as toward former members although they highlight significant disparities among new member states with regard to their convergence toward former members using a time-series approach. In this context, the contribution of this paper is threefold. Firstly, we use the latest update of the Penn World Tables which covers the period from 1990 to 2007. Secondly, we apply the Islam (1995) panel data procedure which allows us to account for potential individual effects. Lastly and more importantly, we explicitly derive a test for the existence of heterogeneity in income convergence speed between Western and Central and Eastern European countries.

[6]Islam (1995) uses the same database as Mankiw et al. (1992)

[7]He considers five year periods to be less influenced by business cycle and less likely to be serially correlated than one year periods.

# 3 Data and Methodology

The data that we use to test convergence in terms of per capital income level are taken from the latest version of the Heston, Summer and Aten's Penn World Tables.[8] In particular, our regressions are based on the GDP per capita in constant prices, the population and the investment share of Gross Domestic Product for the 27 countries of the European Union from 1990 to 2007. Some of these variables need some more explanation. First, as any income variable in the Penn World Tables, GDP per capita is expressed in terms of purchasing power parity. On the other hand, we choose to work with the investment rate rather than with saving rates. Indeed, if the theoretical Solow model uses the saving rate, it also assumes a closed economy in which case the saving rate coincides with the investment rate. Since we work with open economies, the role of foreign investments on the evolution of the stock of capital and hence the steady state is not negligible. That is why we prefer to use investment rates rather than saving rates.[9] In addition, we also follow the hypothesis from Mankiw et al. (1992) on the values of the growth rate of technology and the depreciation rate whose sum is assumed to be common to all countries in the sample and to be equal to 0.05.

The aim of this paper is to test whether the new members of the European Union from Central and Eastern Europe converge to the 15 Western European countries. In addition to testing convergence in the enlarged European Union (27 countries), we also check whether the 10 members from Central and Eastern Europe and the 15 Western European Union countries belong to two different groups in terms of convergence. We base our methodology on the club convergence literature (Durlauf and Johnson (1995) and Fischer and Stirbock (2006)) to test for two different groups in the European Union. More particularly, our tests are based on the comparison of convergence rates for the different groups of countries. However, as opposed to the traditional literature on club convergence, we do not need to make use of any statistical procedure to group countries. Since we want to specifically test the convergence behaviour of the 10 countries of the Eastern bloc, the groups that we consider are imposed by the goal of our paper itself.

[8] Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.3, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, August 2009.

[9] However, in order to remain consistent with the notation from the theoretical Solow model, we use $s$ for the investment rate.

# 4 Results

The main improvement of the panel approach with respect to the cross-sectional method is that it allows for the presence of individual (country) effects. From this point of view, Islam (1995) notably mentions the unobservable initial level of technology, A(0). As a consequence, we first divide the full time period into six shorter time periods of three years in order to obtain a panel. We proceed in three steps. First, we test income convergence for the 27 countries in the European Union and then we apply the same analysis to the two groups of 10 and 15 countries as previously described. One of the concerns of Islam (1995) in the construction of the panel was that shorter period might be influenced among others by business cycles. As a result, the choice of the best length of subperiods involves a trade-off between not being too influenced by business cycles and having enough data on the time dimension. To somewhat reduce the impact of business cycles on our results, we introduce time dummies within our regression. Indeed, these dummies are supposed to capture (at least the part which is common to all the countries) the impact of economic cycles on growth data.
We only report the results from constrained regressions.[10] This constraint is actually rejected in none of the regressions and does not significantly affect the coefficient estimates .
The regression using all the European countries brings some interesting results. First of all, the coefficient on the initial Gross Domestic Product is significantly negative which would be in favor of the hypothesis of convergence in the European Union. However, as suggested by Bernard and Durlauf (1996), it is not implausible to reject the null hypothesis of no convergence within a group of countries although it is actually composed of several groups with different convergence processes.
Besides, individual effects are positively correlated with the explanatory variables and the hypothesis of no significant individual effect is rejected by its related F-test. This would speak in favor of the use of a panel rather than a cross section approach and of the fixed effect methodology rather than the random effect approach.
Focusing on the 15 Western countries members of the European Union before 2004 and on the new entrants separately, we find evidence of significant $\beta$-convergence within both groups.
The main question of our paper is to check whether there exists some heterogeneity in terms of convergence in the European Union between Western

[10] As described in the literature review, the equality (in absolute value) of the coefficients on the saving rate and the combination of population growth, technological growth and depreciation rates is derived from the theoretical Solow model.

Table 1: Regression Results by Group: 1990-2007

| VARIABLES | EU 27 $lny(t) - lny(t-1)$ | Western Countries $lny(t) - lny(t-1)$ | Eastern Countries $lny(t) - lny(t-1)$ |
|---|---|---|---|
| $lny(t-1)$ | -0.285*** | -0.110** | -0.380*** |
| | (0.062) | (0.055) | (0.114) |
| $ln(s) - ln(n_{t1} + g + \delta)$ | 0.174*** | 0.039 | 0.088* |
| | (0.036) | (0.063) | (0.049) |
| $D_{95}$ | 0.103*** | 0.056*** | 0.170*** |
| | (0.016) | (0.012) | (0.033) |
| $D_{98}$ | 0.120*** | 0.077*** | 0.206*** |
| | (0.016) | (0.013) | (0.023) |
| $D_{01}$ | 0.136*** | 0.069*** | 0.254*** |
| | (0.018) | (0.016) | (0.030) |
| $D_{04}$ | 0.159*** | 0.057*** | 0.322*** |
| | (0.022) | (0.019) | (0.036) |
| $D_{07}$ | 0.201*** | 0.087*** | 0.405*** |
| | (0.027) | (0.022) | (0.050) |
| Constant | 2.446*** | 1.050* | 3.188*** |
| | (0.591) | (0.545) | (1.028) |
| $R^2$ | 0.485 | 0.409 | 0.774 |
| Number of countries | 27 | 15 | 10 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

countries and new entrants from Central and Eastern Europe. This can be done in a regression where we allow for different initial income coefficients and different time dummies for both groups. The difference between the two betas coefficients of interest for the two groups is captured in our last regression by the coefficient on the product of the dummy for Eastern Countries and the logarithm of the initial GDP ($lny(t1)_{EAST}$). The results indicate the coexistence of significantly (at the 5% level) different rates of convergence within the European Union and particularly between Western and Eastern countries. While we find evidence of convergence within the European Union (27 countries) for the period between 1990 and 2007, we also show that the rates of convergence from the two groups of countries that we analyze are significantly different using the panel approach with time dummies. This supports the existence of heterogeneous groups of countries within the European Union in terms of convergence rates.

Table 2: Global Regression: 1990-2007

| VARIABLES | $lny(t) - lny(t-1)$ | Standard Errors |
|---|---|---|
| $lny(t-1)$ | -0.110 | 0.076 |
| $lny(t-1)_{EAST}$ | -0.270** | 0.114 |
| $ln(s) - ln(n_{t1} + g + \delta)$ | 0.039 | 0.087 |
| $ln(s)_{EAST} - ln(n_{t1} + g + \delta)_{EAST}$ | 0.049 | 0.094 |
| $D_{95,EAST}$ | 0.170*** | 0.024 |
| $D_{98,EAST}$ | 0.206*** | 0.022 |
| $D_{01,EAST}$ | 0.254*** | 0.022 |
| $D_{04,EAST}$ | 0.322*** | 0.027 |
| $D_{07,EAST}$ | 0.405*** | 0.037 |
| $D_{95,WEST}$ | 0.056*** | 0.017 |
| $D_{98,WEST}$ | 0.077*** | 0.018 |
| $D_{01,WEST}$ | 0.069*** | 0.023 |
| $D_{04,WEST}$ | 0.057** | 0.026 |
| $D_{07,WEST}$ | 0.087*** | 0.030 |
| Constant | 1.888*** | 0.549 |
| $R^2$ | 0.717 | |
| Number of countries | 25 | |

*** p<0.01, ** p<0.05, * p<0.1

# 5 Robustness Check: 1996-2007

As a robustness check of our results, we repeat the same methodology to the period from 1996 to 2007 using a panel of 4 periods of 3 years. Indeed, the first years of our original panel coincide with the period directly following the shift from a planned to a market economy for the countries from the former Soviet bloc. This transformation obviously required institution changes which might have impacted the process of economic growth in these countries. As a result, by eliminating these early years of our panel, we explicitly try to obtain results free from any bias arising from the transition process.

While the convergence rates in the European Union and within both groups are slightly different from those obtained using the entire panel, the conclusions in terms of heterogeneity of income convergence within the European Union remain unchanged. In addition, the $R^2$ of the regression for

Table 3: Regression Results by Group: 1996-2007

| VARIABLES | EU 27 $lny(t) - lny(t-1)$ | Western Countries $lny(t) - lny(t-1)$ | Eastern Countries $lny(t) - lny(t-1)$ |
|---|---|---|---|
| $lny(t-1)$ | -0.170*** | -0.198*** | -0.416*** |
| | (0.054) | (0.047) | (0.090) |
| $ln(s) - ln(n_{t1} + g + \delta)$ | 0.136*** | 0.138*** | 0.109*** |
| | (0.031) | (0.046) | (0.039) |
| $D_{01}$ | 0.006 | -0.003 | 0.049*** |
| | (0.010) | (0.008) | (0.016) |
| $D_{04}$ | 0.018 | -0.005 | 0.121*** |
| | (0.013) | (0.010) | (0.025) |
| $D_{07}$ | 0.050*** | 0.025* | 0.208*** |
| | (0.017) | (0.013) | (0.038) |
| Constant | 1.503*** | 1.849*** | 3.688*** |
| | (0.502) | (0.468) | (0.800) |
| $R^2$ | 0.293 | 0.626 | 0.641 |
| Number of countries | 27 | 15 | 10 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

the 27 countries is lower those of the regression by groups which may also be seen as evidence for the coexistence of two significantly different groups of convergence within the European Union.

# 6 Conclusions

This paper aims at testing whether the new European Union members from Eastern Europe were already exhibiting a convergence process toward members. In particular, we test for the existence of two heterogeneous groups of countries with different convergence rates. The presence of heterogeneity within the European Union could have implications on the efficiency of functioning of the European Union and the Eurozone as the recent Greece's sovereign debt crisis has highlighted. We find a significant rate of convergence for the 27 countries composing European Union. More importantly, our global regression based on the Islam's framework including dummies for time shows that Western European countries and newcomers from Eastern and Central Europe display significantly different rates of convergence hence supporting the idea of heterogeneity in the European Union. These results are robust to changes in the period of analysis. However, whether the joining

Table 4: Global Regression: 1996-2007

| VARIABLES | $lny(t) - lny(t-1)$ | Standard Errors |
|---|---|---|
| $lny(t-1)$ | -0.198*** | 0.068 |
| $lny(t-1)_{EAST}$ | -0.218** | 0.095 |
| $ln(s) - ln(n_{t1} + g + \delta)$ | 0.138** | 0.067 |
| $ln(s)_{EAST} - ln(n_{t1} + g + \delta)_{EAST}$ | -0.028 | 0.073 |
| $D_{01,EAST}$ | 0.049*** | 0.012 |
| $D_{04,EAST}$ | 0.121*** | 0.018 |
| $D_{07,EAST}$ | 0.208*** | 0.028 |
| $D_{01,WEST}$ | -0.003 | 0.012 |
| $D_{04,WEST}$ | -0.005 | 0.015 |
| $D_{07,WEST}$ | 0.025 | 0.019 |
| Constant | 2.585*** | 0.469 |
| $R^2$ | 0.637 | |
| Number of countries | 25 | |

*** p<0.01, ** p<0.05, * p<0.1

of these Eastern Countries will reduce this heterogeneity is still a question to be answered in future research. In addition, it might be of prime importance to verify the disappearance of this significant heterogeneity before all the newcomers are allowed to join the Eurozone.

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